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Microstrip miniaturised antennas

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Abstract This paper deals with the various techniques for reduction in the size of the antennas A small microstrip patch antenna is presented The probe-fed microstrip patch incorporates a single shorting post which significantly reduces the overall size of the antenna Theoretical impedance behaviour and radiation characteristics of the modified patch are given.

Keywords Microstrip antennas, design and simulation results

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1. Introduction

In the present scenario of increase in demand by the system designers for the implementation of more complex functions in reduced space, there is an increase in the demand for the active integrated microstrip patch antennas with lower size and weight. This paper addresses these demands by describing various techniques to satisfy the severe constraints on the physical dimensions, the need for "miniaturisation" of the patch antennas. Such light weight and low volume antennas could find applications in land, mobile and personal communication systems and airborne antenna systems.

The half-wavelength ($\lambda/2$) open-circuited microstrip patch antenna is used because of both its conventional property and relative ease to manufacture. Miniaturisation of the resonant microstrip patch antennas can be accomplished by loading. Loading can take various forms, namely (i) use of substrates and/or superstrates of higher permittivity, (ii) modification of basic patch geometry and (iii) use of short-circuiting posts These are briefly described below.

Loading the resonant antenna with the high permittivity dielectric material reduces the size of the antenna [1]. Although the reduction of antenna dimensions by dielectric loading has been carried out since antennas were first used, practical implementation has been closely tied to the availability and competitive and economical cost of dielectric materials in industry. On one hand high permittivity substrates can improve some antenna characteristics, they are, on the other hand, invariably ceramic-based which require specialized machining equipment as compared to that required for plastic substrates.

To achieve smaller planar antennas operating at the same frequencies as conventionally configured antennas requires a more complex geometry. One of the geometry is C-patch microstrip antenna formed by cutting a small area in one of the radiating edges of the antenna [2]. A similar technique uses H-shaped or rectangular ring microstrip patch, which consists of a strip of metal, H-shaped or rectangular ring-shaped supported on the grounded dielectric sheet. It has a size about half that of the rectangular patch, with larger beamwidth but smaller bandwidth. Other miniaturisation shapes include the double C-patch (two stacked C-shaped antenna elements connected together with a vertical ground plane) [3], annular slot and the annular sector. Some of the other shapes make inefficient use of the available area and an adequate performance can only be achieved either by super-conducting material or thick low-loss substrates.

Common technique to reduce the overall size of a microstrip patch antenna is to terminate one of the radiating edges with a short circuit [4]. The short circuit can be in the form of a metal clamp or a copper sheet wrapped around the

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edge or a series of shorting posts located near the feed of the antenna. These modified patches are approximately a quarter-wavelength in length and generally have a wider beamwidth compared to conventionally sized patches. However, this also eliminates the mutual coupling between the two sources and the bandwidth is reduced by about one-fifth.

Reducing the overall length of a quarter-wavelength ($\lambda/4$) shorted patch to less than $\lambda/8$ is possible by replacing the coax feed by a capacitive feed [5]. The capacitive load is formed by folding the open end of the patch towards the ground plane and adding a plate (parallel to the ground plane).

2. Antenna design and simulation results

As was evident in [4], although reducing the number of shorting posts effectively reduces the size of the patch, the input impedance at resonance becomes significantly larger. This is indeed the case when using a single shorting post. It was found that to reduce the input impedance at resonance to close to 50 Ω, very small conductors for both the coaxial feed and the shorting post must be used and also these conductors must be located in close proximity. In the design of the probe-fed circular microstrip patch with a single shorting post, the short-circuit was moved slightly away from the patch conductor edge The reasons for doing so were to ease the tolerances on the etching of the patch as well as to reduce the likelihood of exciting higher order modes in the vicinity of the post.

Figure 1 shows the geometry of the probe-fed circular microstrip patch with a single shorting post The radius of

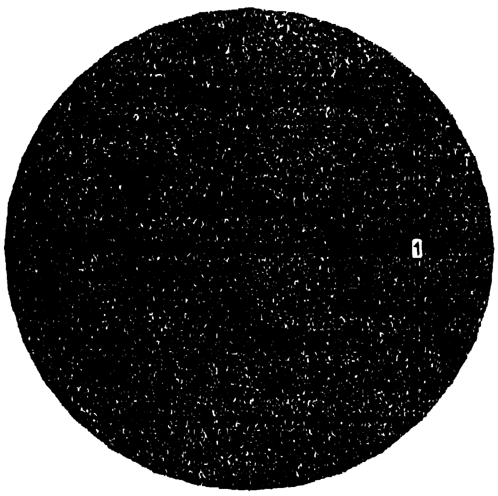

Figure 1. Geometric layout of probe-fed circular microstrip patch antenna with a single shorting post

this modified circular patch is 9.19 mm, ~$0.047\lambda_0$ (where λ_0 is the free space wavelength). This compares with a conventional circular patch (mounted on the same substrate and designed to resonate at the same frequency) with the radius of 27.1 mm, ~ $0.14\lambda_0$. To accurately predict the impedance behavior and the radiation characteristics of the modified probe-fed circular patch, IE3D software [6] was used. Figure 2 shows the return loss characteristic of the

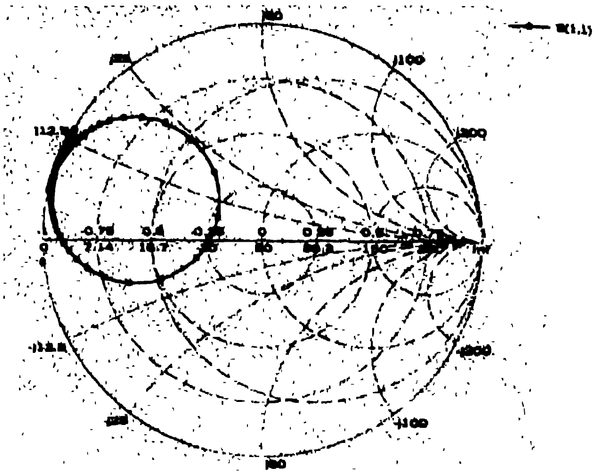

Figure 2. Impedance behavior of the modified patch (Smith chart)

above patch. The theoretical impedance behavior of the shorted patch is shown in Figures 3 and 4 while the

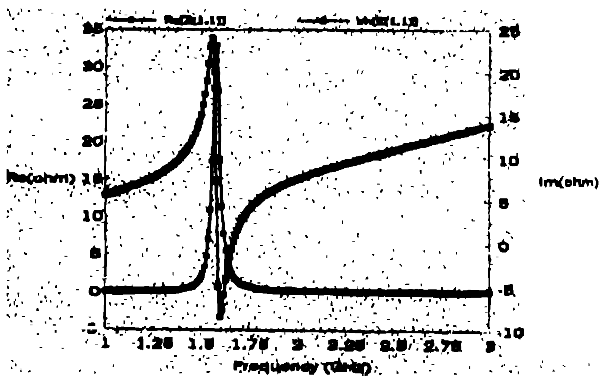

Figure 3. Impedance characteristics of shorted microstrip patch antenna.

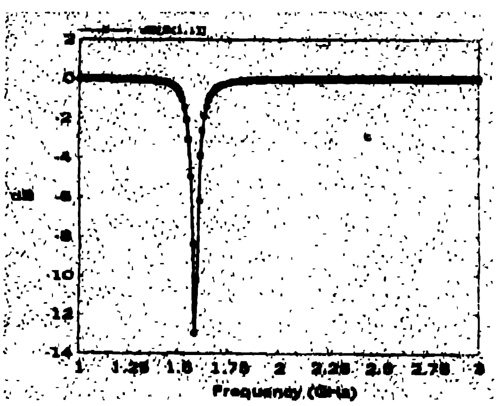

Figure 4. Return loss of shorted microstrip patch antenna

radiation characteristics of the modified patch are shown in Figure 5.

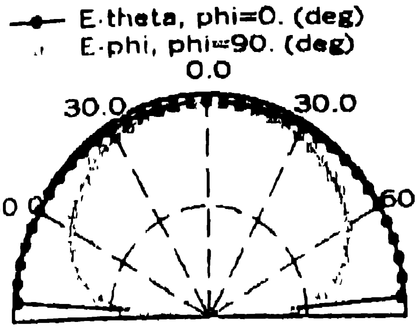

Figure 5. Simulated E-plane and H-plane radiation patterns of shorted microstrip patch.

3. Conclusions

A small microstrip patch antenna has been analysed. The probe-fed microstrip patch with a single shorting post is significantly smaller in size than conventional microstrip patch antennas and is thus suitable for applications where limited antenna real estate is available.

Acknowledgment

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